

Food Poisoning Outbreaks Associated with Spray-Dried Milk—An Epidemiologic Study

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Described are a series of nineteen outbreaks of gastroenteritis occurring during a one-month period among school children. Epidemiologic study and a human volunteer experiment implicated spray-dried milk solids. Though bacteriologic and toxicologic tests were negative, clinical and epidemiologic evidence indicated that staphylococcal enterotoxin was the probable agent.

Outbreaks

Between January 23 and February 21, 1956, there were reported 19 separate outbreaks of acute gastroenteritis among children participating in the school lunch program in Puerto Rico. These outbreaks were, with two exceptions, localized in metropolitan San Juan. The outbreaks were reported from 16 schools, three having experienced two such episodes. In all, 775 children of the 4,094 eating at these lunchrooms were ill.

Principal symptoms were those of nausea, vomiting, abdominal pain, and diarrhea without fever beginning one to five hours following noontime school lunch. Although a substantial number of severe cases were taken to municipal hospitals for emergency treatment, there was virtually complete recovery within 24 hours. No deaths were reported.

Epidemiologic evidence pointed to spray-dried, nonfat milk powder as the responsible food and clinical symptomatology and incubation period to staphylococcal enterotoxin as the responsible agent. Although food poisoning related to spray-dried milk has been reported

on one previous occasion from England¹ these outbreaks represent the first such related instances of food poisoning in the United States. For this reason the various aspects of this series of outbreaks are presented in some detail.

Investigation

As soon as was practicable after each of the outbreaks was reported—within at most 48 hours—investigations were undertaken by either personnel from the Commonwealth Health Department or by one of us (R.A.). Reports of numbers of children experiencing illness were obtained from school authorities. Randomly selected groups of children, including those both ill and not ill, were individually interviewed about the menu items consumed. To determine the responsible food the epidemiologic statistical method was used² utilizing attack rates for foods consumed

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and, conversely, for those not consumed.

It became apparent upon investigation that there was no common source exposure for the children other than foods consumed at the school lunch-rooms, but identification of the particular food item presented substantial problems. Conflicting pictures were presented as a result of inaccurate information given by young children who were under varying psychologic pressures to consume "everything" and there were other unforeseen variables which are to be discussed later. Because in some outbreaks there were strong indications that milk was responsible, arrangements were made in early February for the exchange of milk stocks in the San Juan schools for milk stocks most recently received on the island. Despite this exchange, several additional identical outbreaks occurred following the use of the newly distributed milk.

Particular efforts had been made to obtain leftover food from the lunch-rooms following outbreaks, but they were generally futile as food items had usually been totally consumed or discarded prior to our arrival. Over 90 samples of 17 foodstuffs that were obtained and submitted to the Commonwealth Health Laboratories were negative bacteriologically and toxicologically. However, on February 14 an opened can of spray-dried, nonfat milk solids was obtained which had been partially consumed at the Sonadora Llana School on the day previous, the day of the outbreak. From this can powder was obtained and a glass of the reconstituted milk was consumed by one of us (R.A.). Two hours following ingestion there occurred the sudden onset of nausea, pyrosis, dizziness, abdominal cramps, and profuse diarrhea, the symptoms subsiding in about four hours.

On the basis of this observation and because of repeatedly negative laboratory examinations a human feeding ex-

periment was undertaken utilizing 26 adult volunteers. Reconstituted milk in the proportions and volume used by the schools, i.e., one ounce of powder to eight ounces of water, was prepared in a single container and poured into 13 glasses. Commercially purchased nonfat milk solids were prepared similarly and poured into another 13 glasses. Volunteers were allowed random selection of the glasses which had been coded and comingled. The milk was immediately consumed and the volunteers sent to their respective homes with the request that they eat nothing for four hours.

Marked vomiting, diarrhea, cramps, weakness, and dizziness ensued among five of the 13 who consumed the suspect milk between one and two hours following ingestion. Milder symptoms were experienced by four others in this group. Among those consuming the commercially obtained milk, two experienced very mild symptoms three and six hours, respectively, following ingestion (Table 1).

Studies of samples of this milk conducted by the Food and Drug Administration Laboratories, Washington, D. C., were reported to show a plate count of thirty thousand bacterial colonies and a direct microscopic count of over one billion, per gm of solids. No pathogenic organisms were isolated. Toxicologic studies by the Commonwealth Health Laboratories were entirely negative for metallic poisons. As a result of this experiment, the use of nonfat, spray-dried milk solids was ended and with the termination—despite the continued use of all other foodstuffs in the school lunch program—outbreaks on the island ceased abruptly.

Although the human volunteer experiment would indicate that the suspected enterotoxin was present in the milk powder prior to reconstitution, for further supporting evidence, data were gathered at 16 of the schools relating to

Table 1—Summary of Feeding Experiment with Human Volunteers
A. Test Group

No.	Sex	Age	Incubation Period Hours	Symptoms			Other Complaints	Comments
				Vomit- ing	Diar- rhea	Abdom- inal Pain		
1	F	37	2	+++	+++	+++	Dizziness, cold sweat, stupor, hematemesis	Hospital- ized 3 days
2	F	37	1	+++	+++	+++	Salivation, dizziness, cold sweat	Recovered 24 hours
3	F	22	1-¾	+++	+++	+	Headache, dizziness, weakness	Recovered 24 hours
4	F	37	2	+++	+	+	Dizziness, weakness, pirosis	Recovered 24 hours
5	F	27	2	++	++	+	Cold sweat, dizziness	Recovered 24 hours
6	M	33	—	—	—	—	None	.....
7	M	33	1	+	—	+	Salivation, hyper- peristalsis	Recovered 4 hours
8	M	32	—	—	—	—	Meteorism, belching	Recovered 1 hour
9	F	26	7	—	+	++	Meteorism	Recovered 1 hour
10	F	43	—	—	—	—	None	.....
11	F	38	—	—	—	—	None	.....
12	F	30	—	—	—	—	None	.....
13	M	34	2	—	++	+	Nausea, belching pirosis, malaise	Recovered 4 hours

B. Control Group

1	F	20	6-½	++	—	—	None	Symptoms Occurred after Seeing One of Ill Test Subjects and Persisted About 2 hours
2	F	26	3	—	+	—	None	4-5 Stools Over 8-hour period
3	M	54	—	—	—	—	"	.....
4	F	22	—	—	—	—	"	.....
5	M	43	—	—	—	—	"	.....
6	M	44	—	—	—	—	"	.....
7	F	27	—	—	—	—	"	.....
8	M	52	—	—	—	—	"	.....
9	M	40	—	—	—	—	"	.....
10	M	45	—	—	—	—	"	.....
11	F	64	—	—	—	—	"	.....
12	F	30	—	—	—	—	"	.....
13	M	34	—	—	—	—	"	.....

+++ = Severe

++ = Moderate

+ = Mild

the time elapsed between reconstitution of the milk and service at lunch. Since the milk is reconstituted with warm water and allowed to remain unrefrigerated prior to dispensing, it might be postulated that if staphylococci were in the powder, a period of incubation might allow production of enterotoxin. However, in nine schools this period of possible incubation was less than three hours and in no instance longer than five hours.

Puzzling at first was the concentration of the outbreaks in the San Juan area almost to the exclusion of other parts of the island. Reconstituted dried milk is consumed in substantial quantities throughout the island and it was felt that the prominent newspaper publicity given the epidemic would have brought additional outbreaks to our attention.

From the map (Figure 1) it is apparent that the schools experiencing outbreaks received their milk from but three of the 14 distributing food warehouses. The San Juan warehouse supplied 14 of the schools in which 17 outbreaks occurred and the remaining two schools were supplied by two dif-

ferent warehouses. The concentration of outbreaks in the San Juan area was determined to be the result of the San Juan warehouseman dispensing to his area primarily the most recently received milk shipments, while other distributing warehouses were dispensing older stock. The two outbreaks related to the Arecibo and Arroyo warehouses followed almost immediately an order in mid-February to all warehousemen requesting that they dispense only the most recently received stocks. A review of dried milk inventories at the various warehouses confirmed this to be the case.

Symptoms, Incubation Period, Age and Sex Distribution

Information obtained by interview of 267 cases at nine schools was pooled for study of the nature of the illness. The incubation period could be determined with reasonable accuracy in 194 cases (Table 2). For the remaining 73 children the time of onset, although less than six hours in all instances, could not be accurately determined. Of the group

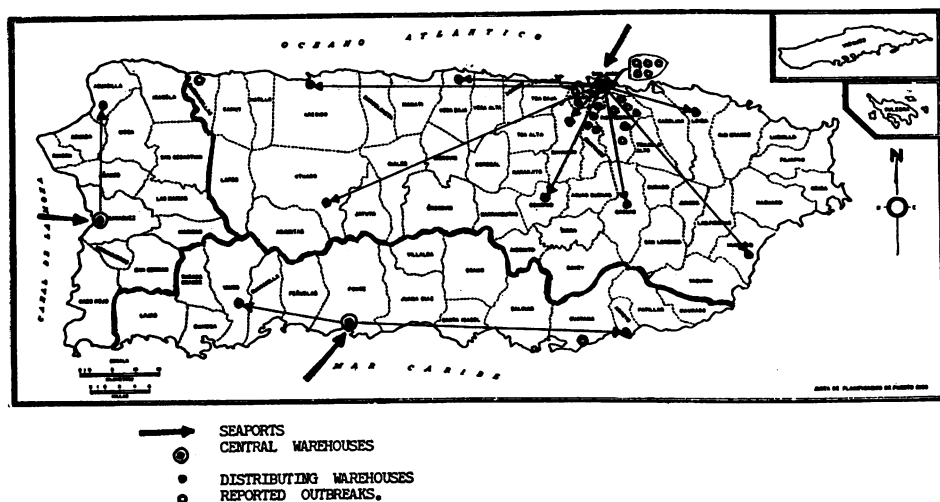


Figure 1—Network of Milk Distributing Warehouses and Distribution of Outbreaks Puerto Rico, 1956

studied the peak occurrence of cases was between two and three hours with 84 per cent having had onsets within four hours. The most frequently reported symptoms were those of abdominal pain and vomiting, followed in order by diarrhea, dizziness, and nausea without vomiting (Table 3).

Attack rates appeared, at first, to vary widely between schools when the total number ill was considered with reference to the number eating in the lunchrooms. However, upon detailed study it became apparent that in many of the schools milk had been reconstituted in two or more large kettles and in so doing milk was used from more than one shipping carton and, hence, probably more than one processor source. The best example of this was obtained at Goyco School, where lunch was served in two shifts, the milk having been reconstituted in two, nine-gallon kettles. The milk from one kettle and half that from the second was used for the first shift; the remainder for the second shift. The attack rate for the first shift was 12 per cent, for the second, 39.6 per cent, indicating significant contamination was probably present in only one of the two kettles.

Because in all other schools where two or more kettles were used, denom-

Table 3—Frequency of Symptoms Among 267 Cases in Nine Schools Studied

Symptom	No.	Per cent
Abdominal pain	228	85.3
Vomiting	187	70.0
Diarrhea	104	39.0
Dizziness	96	36.0
Nausea	24	9.0

inator information could not be so clearly defined. In order to analyze age- and sex-specific attack rates we decided to make a pool of data obtained from those schools experiencing outbreaks where children had been served from one kettle only. Information from five schools could be so pooled. Analysis of these data indicates a somewhat higher attack rate among females than males in all age groups. The over-all attack rate was 36 per cent for females and 27 per cent for males. Although there is a suggestion of a decreasing susceptibility with age when the group is considered as a whole, this is not borne out when the sexes are considered separately.

Definition of Suspect Lots by Epidemiologic Method

Spray-dried milk solids have been used in Puerto Rican government programs for over 10 years without previously reported trouble. Some four million pounds are now used annually. Recognizing that substantial quantities of spray-dried milk solids from the United States have been distributed throughout the world without previous report of difficulty, we felt it probable that but few of the more than 225 lots of milk on hand were contaminated.

At the time the outbreaks were occurring investigators recorded only identification appearing on the separate

Table 2—Time Interval Between Lunch and Onset of First Symptoms Among 194 Cases in Nine Schools

Incubation Period (Hours)	No. of Cases	Per cent
Less than 1	23	11.8
1	48	24.7
2	56	28.9
3	36	18.6
4	19	9.8
5	8	4.1
6 or more	4	2.1
Total	194	100.0

cans obtained at the schools. These cans containing four and one-half pounds were packed six to a cardboard container. However, it was subsequently discovered that this identification did not define the milk processor. Information about which of seven processors might have been responsible could be obtained only by reference to two sets of numbers stamped on the cardboard carton. Further investigation at the schools to unearth suspect lot numbers was impossible for all school milk stocks had been returned to central warehouses.

A more devious and complicated study became necessary. Information was gathered from invoice slips as to lot numbers received in the previous eight monthly boat shipments to the island. Records of milk shipments from the three Puerto Rican ports to the distributing warehouses were obtained and an inventory of milk stocks on hand at these warehouses was compiled.

From the records it was apparent that milk from the first four shipments had been distributed and used more or less uniformly throughout the island. The fifth shipment had not been distributed to any of the San Juan schools. The eighth shipment had been received and held intact. Shipments number six and seven had been distributed by only four of the 13 warehouses and the San Juan warehouse accounted for the bulk of that distributed. Thus two of the eight shipments came under immediate suspicion. These shipments comprised a total of 963,000 pounds of milk in 20 lots. It had been processed by seven different companies. Inventories of these shipments revealed that less than 2.7 per cent of the first shipment and 1.3 per cent of the second had actually been used. Of that used, about 80 per cent had been by San Juan metropolitan schools.

Fortunately, milk stocks returned during the milk exchange from 66 schools, eight of which had experienced outbreaks and 58 which did not, had been retained in separate piles after their return to the warehouses. Lot numbers on the cases revealed that of the 20 lots received in the suspect December and January shipments, only two were represented in the stocks of every school experiencing an outbreak. These were returned from but four of the 58 schools which had experienced no outbreaks. One additional suspect lot number was obtained from a carton which had been retained for storage purposes at a school which had experienced an outbreak on the day milk from this carton was used.

Sometime after completion of the studies identifying information for the code numbers stamped on the cartons was obtained. This information indicated that all three suspect lots had been produced by but one of the seven processing plants.

Comparative Bacterial Plate Count Analyses of the Processing Plants

Samples of all dried milk processed are submitted to the Dairy Inspection Laboratory, U. S. Department of Agriculture, for plate count analysis prior to release for distribution. A sample of milk powder from each processed dried milk batch (usually 3,825 pounds) is tested. Laboratory records were made available to us by the Department of Agriculture relating to lots of milk processed for Puerto Rico between August 15, 1955, and January 12, 1956.

The records of production by the seven processors involved in supplying milk (Table 4) indicate that one company produced batches with substantially higher over-all bacterial plate counts than any of the other companies. Significantly, the three lots of milk previously suspect through epidemio-

Table 4—Reported Bacterial Plate Count, by Batches, from Seven Processors Supplying Milk to Puerto Rico, August 15, 1955–January 12, 1956

Bacterial Plate Count (in Thousands) per gm of Solids	A	B	C	D	E	F	G
Less than 5	50	9	92	61	175	15	77
5–10	74	3	2	25	22	0	0
11–15	23	0	0	0	0	0	0
16–20	40	0	0	0	0	0	0
21 and over	14	0	0	1	—	0	0
	201	12	94	87	197	15	77

logic study were produced by this same company.

Discussion

Gastroenteritis outbreaks of staphylococcal enterotoxin etiology are certainly quite common. However, spray-dried milk solids have been incriminated in but one previous series of outbreaks. These occurred in England and after thorough study implicated milk processed there.^{1, 3, 4} Because of the increasing and now very substantial quantity of production and widespread distribution of spray-dried milk, this series of outbreaks in Puerto Rico assumes considerable significance.

Although bacteriologic studies were negative, the clinical symptomatology and incubation period, in the light of negative toxicologic findings, strongly implicates staphylococcal enterotoxin as the responsible agent. Indicative, but not conclusive, food histories suggested spray-dried milk as the responsible food. Confirmation of this was achieved by human volunteer experiment. The unusual geographic pattern of the outbreaks was explainable through particular irregularities of the milk distribution from warehouses. Epidemiologic evidence indicated at least three particular lots of milk from one of the seven

processing plants involved. Bacteriologic plate count records of samples from this plant were shown to be clearly in excess of those submitted by the other plants.

Evidence that the staphylococcal enterotoxin was present in the dried milk prior to reconstitution was adduced from the human volunteer experiment in which the milk was consumed almost immediately after reconstitution. This was substantiated by studies at the schools where it was found that in nine of 16 schools the milk had been allowed to stand less than three hours following reconstitution. Anderson and Stone¹ showed that even with reconstitution of the milk in an artificial cream preparation, little staphylococcal multiplication occurs until after a six- to seven-hour period elapses.

Considering that the staphylococcal organism is much more sensitive to heat than its enterotoxin product it seems reasonable to postulate that the negative bacteriologic results obtained in this present series of outbreaks might well be the result of the destruction of the organism but not the toxin. A plate count of milk used in the human volunteer experiment revealed but 30,000 colonies per gm of solids, a figure ordinarily certifying the milk to be "extra grade." That the staphylococcus is

more sensitive to heat than its enterotoxin product is commonly recognized. Anderson and Stone¹ have demonstrated that momentary heat drying in the production of dried milk is insufficient to destroy formed enterotoxin.

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New Maternal Welfare Committee Name

The name of the American Committee on Maternal Welfare has been changed to the American Association for Maternal and Infant Health. According to its retiring president, Frederick H. Falls, M.D., the purpose of the change is to point up the development of maternity care from strictly a medical problem to that of a complex professional service involving many specialists other than medicine. The new American Association for Maternal and Infant Health will provide the close integration of all the disciplines, along with the

paramount role of the obstetrician—nurse, pediatrician, hospital administrator, nutritionist, social worker, public health nurse, and a host of other workers. The Association further will raise money for education and research in the field of human reproduction.

At the Seventh American Congress held in Chicago, June 7–12, Bayard Carter, M.D., professor and head, Department of Obstetrics and Gynecology, Duke Hospital, Durham, N. C., was elected president. The 8th Congress on Maternal Welfare will be held in 1960.